

# **USB-TC-AI**

Thermocouple and Voltage Measurement

## User's Guide

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## About this User's Guide

### What you will learn from this user's guide

This user's guide describes the Measurement Computing USB-TC-AI data acquisition device and lists device specifications.

### Conventions in this user's guide

#### For more information

Text presented in a box signifies additional information related to the subject matter.

**Caution!** Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

**bold** text      **Bold** text is used for the names of objects on a screen, such as buttons, text boxes, and check boxes.

*italic* text      *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

### Where to find more information

Additional information about USB-TC-AI hardware is available on our website at [www.mccdaq.com](http://www.mccdaq.com). You can also contact Measurement Computing Corporation with specific questions.

- Knowledgebase: [kb.mccdaq.com](http://kb.mccdaq.com)
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: [techsupport@mccdaq.com](mailto:techsupport@mccdaq.com)

## Introducing the USB-TC-AI

The USB-TC-AI is a USB 2.0 full-speed, thermocouple input module that is supported under popular Microsoft® Windows® operating systems. The USB-TC-AI is fully compatible with both USB 1.1 and USB 2.0 ports.

The USB-TC-AI provides eight analog input channels that are configured as four differential temperature inputs and four differential or single-ended voltage inputs. A 24-bit analog-to-digital (A/D) converter is provided for each pair of analog inputs. Eight independent, TTL-compatible digital I/O channels are provided to monitor TTL-level inputs, communicate with external devices, and to generate alarms. The digital I/O channels are software programmable for input or output.

The temperature channels are software programmable for different thermocouple types. You can take measurements from type J, K, R, S, T, N, E, and B thermocouples.

The voltage input range is software programmable for  $\pm 10$  V,  $\pm 5$  V,  $\pm 2.5$  V,  $\pm 1.25$  V.

The USB-TC-AI provides a integrated cold junction compensation (CJC) sensor for thermocouple measurements. An open thermocouple detection feature lets you detect a broken thermocouple.

An on-board microprocessor automatically linearizes the measurement data.

The USB-TC-AI is a standalone plug-and-play module which draws power from the USB cable. No external power supply is required. All configurable options are software programmable.

The USB-TC-AI is fully software calibrated.

## Functional block diagram

USB-TC-AI functions are illustrated in the block diagram shown here.

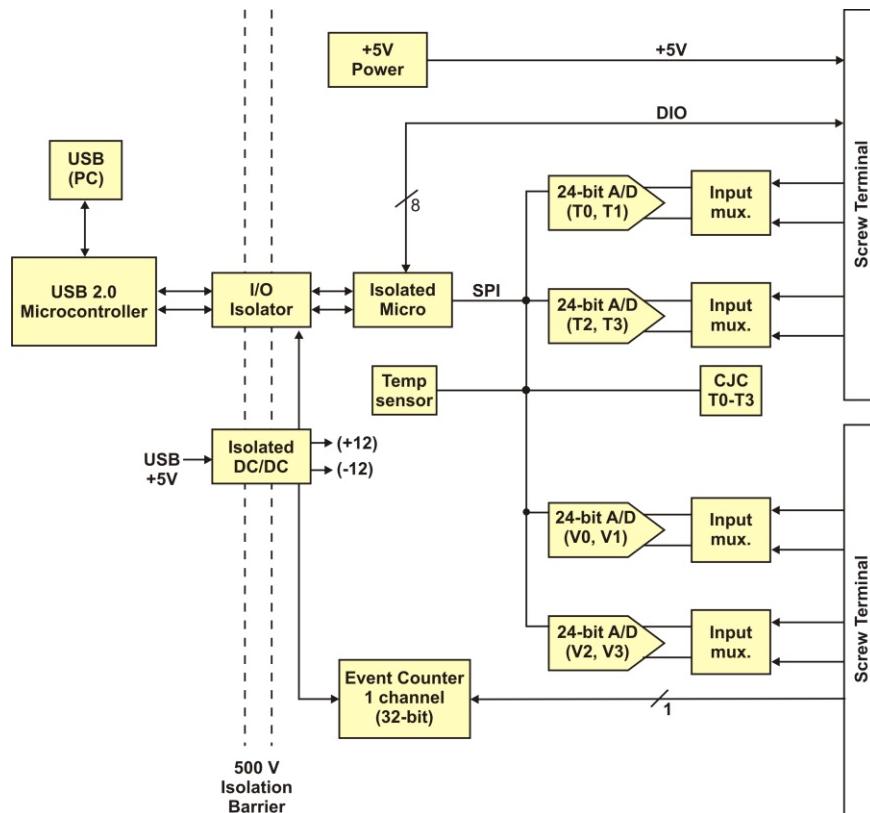


Figure 1. USB-TC-AI functional block diagram

## Connecting a USB-TC-AI to your computer is easy

Installing a data acquisition device has never been easier.

- The USB-TC-AI relies upon the Microsoft Human Interface Device (HID) class drivers. The HID class drivers ship with every copy of Windows that is designed to work with USB ports. We use the Microsoft HID because it is a standard, and its performance delivers full control and maximizes data transfer rates for your USB-TC-AI. No third-party device driver is required.
- The USB-TC-AI is plug-and-play. There are no jumpers to position, DIP switches to set, or interrupts to configure.
- You can connect the USB-TC-AI before or after you install the software, and without powering down your computer first. When you connect an HID to your system, your computer automatically detects it and configures the necessary software. You can connect and power multiple HID peripherals to your system using a USB hub.
- You can connect your system to various devices using a standard USB cable. The USB connector replaces the serial and parallel port connectors with one standardized plug and port combination.
- You do not need a separate power supply module. The USB automatically delivers the electrical power required by each peripheral connected to your system.
- Data can flow two ways between a computer and peripheral over USB connections.

# Installing the USB-TC-AI

## What comes with your shipment?

The following items are shipped with the USB-TC-AI:

### Hardware

- USB-TC-AI
- USB cable (2 meter length)

### Documentation

In addition to this hardware user's guide, you should also receive the *Quick Start Guide*. This booklet provides an overview of the MCC DAQ software you received with the device, and includes information about installing the software. Please read this booklet completely before installing any software or hardware.

## Unpacking

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the USB-TC-AI from its packaging, ground yourself using a wrist strap or by simply touching the computer chassis or other grounded object to eliminate any stored static charge.

If any components are missing or damaged, contact us immediately using one of the following methods:

- Knowledgebase: [kb.mccdaq.com](http://kb.mccdaq.com)
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: [techsupport@mccdaq.com](mailto:techsupport@mccdaq.com)

For international customers, contact your local distributor. Refer to the International Distributors section on our website at [www.mccdaq.com/International](http://www.mccdaq.com/International).

## Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the MCC DAQ CD. This booklet is available in PDF at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf).

## Installing the hardware

To connect the USB-TC-AI to your system, turn your computer on, and connect the USB cable to a USB port on your computer or to an external USB hub that is connected to your computer. The USB cable provides power and communication to the USB-TC-AI.

When you connect the USB-TC-AI for the first time, a notification message opens as the USB-TC-AI is detected. When this message closes, the installation is complete. The upper **LED** (Activity) blinks when initially connected and then stays on. The lower LED (USB) turns on to indicate that communication is established between the device and computer.

### If the LED turns off

If the LED is on but then turns off, the computer has lost communication with the USB-TC-AI. To restore communication, disconnect the USB cable from the computer, and then reconnect it. This should restore communication, and the LED should turn back on.

## Configuring the hardware

All hardware configuration options on the USB-TC-AI are programmable with software. Use InstaCal to set the thermocouple type for each channel pair.

Use InstaCal to set the thermocouple type for each for each pair of temperature channels, and the range and input configuration of each voltage channel. Any channel you don't intend to use should be left disabled.

Configuration options are stored on the USB-TC-AI 's isolated microcontroller in EEPROM, which is non-volatile memory on the USB-TC-AI module. Configuration options are loaded on power up. The factory default configuration is *Type J* thermocouple.

### Default configuration

The factory default configuration for the voltage inputs is *Disabled*. The Disabled mode disconnects the analog inputs from the terminal blocks and internally grounds all of the A/D inputs.

### Warm up

Allow the USB-TC-AI to warm up for 30 minutes after powering up before taking measurements. This warm up time minimizes thermal drift and achieves the specified rated accuracy of measurements.

## Calibrating the hardware

The USB-TC-AI is fully calibrated via InstaCal. Allow the USB-TC-AI to operate for at least 30 minutes before calibrating. This warm up time minimizes thermal drift and achieves the specified rated accuracy of measurements.

# Signal I/O Connections

## Screw terminal pinout

The USB-TC-AI has four rows of screw terminals — two rows on the top edge of the housing, and two rows on the bottom edge. Each row has 26 connections. Between screw terminals 10 and 11 is the integrated CJC sensor used for thermocouple measurements. Signals are identified in Figure 2.

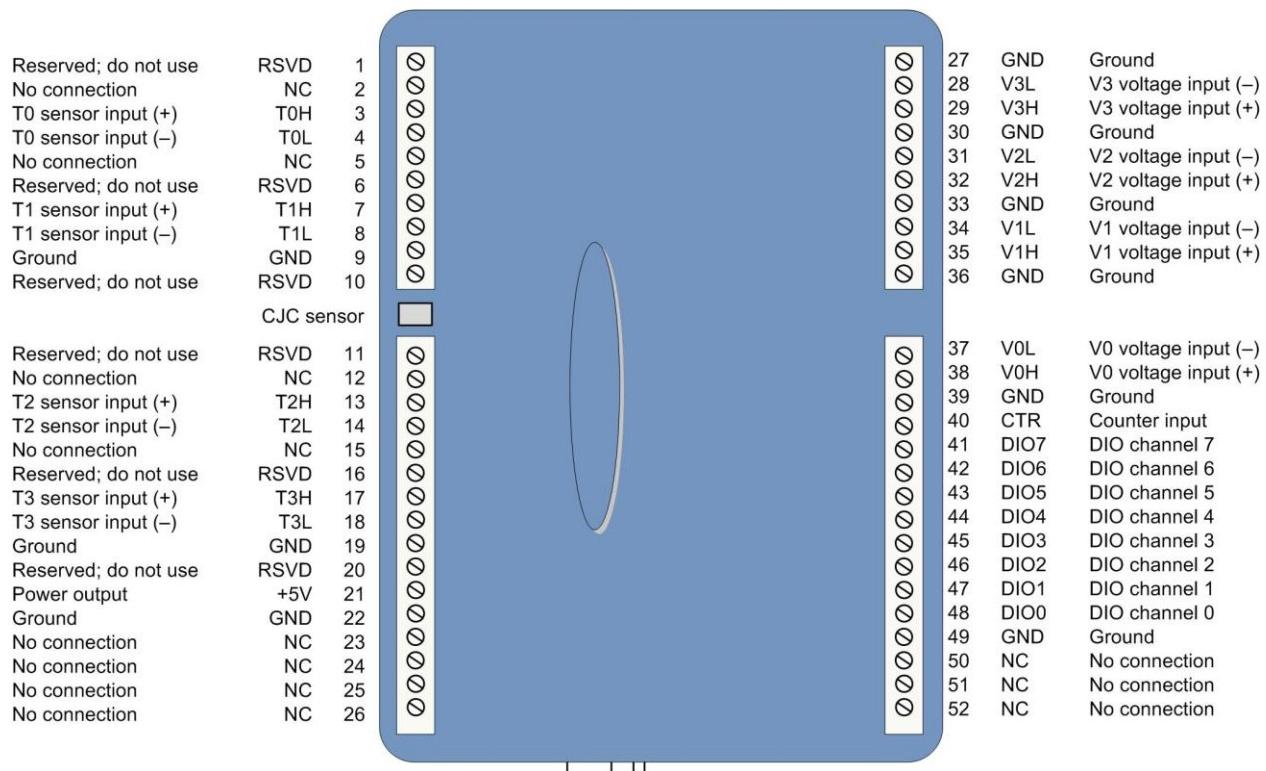


Figure 2. USB-TC-AI screw terminal pin numbers

Use 16 AWG to 30 AWG wire for your signal connections.

#### **Tighten screw terminal connections**

When making connections to the screw terminals, be sure to tighten the screw until tight. Simply touching the top of the screw terminal is not sufficient to make a proper connection.

## Voltage input

You can connect up to four voltage inputs to the voltage channels (**V0H/V0L** to **V3H/V3L**). The input range is software programmable for  $\pm 10\text{ V}$ ,  $\pm 5\text{ V}$ ,  $\pm 2.5\text{ V}$ , or  $\pm 1.25\text{ V}$ . Each voltage channel is software configurable for differential or single-ended mode.

When connecting differential inputs to floating input sources, you must provide a DC return path from each differential input to ground. One way to do this is to connect a resistor from one side of each of the differential inputs to GND. A value of approximately 100 k $\Omega$  can be used for most applications.

**Caution!** All ground pins on the USB-TC-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Thermocouple input

You can connect up to four thermocouples to the differential sensor inputs (**T0H/T0L** to **T3H/T3L**). The device supports type J, K, R, S, T, N, E, and B thermocouples. You can mix thermocouple types.

### Thermocouple selection

The thermocouple type you select will depend on your application needs. Review the temperature ranges and accuracies of each type to determine which is best suited for your application.

## CJC sensor

The USB-TC-AI has one built-in high-resolution temperature sensor. The CJC sensor measures the ambient temperature at the terminal block so that the cold junction voltage can be calculated.

## Digital I/O

You can connect up to eight digital I/O lines to the screw terminals labeled **DIO0** to **DIO7**. Each terminal is software configurable for input or output.

## Counter input

The **CTR** terminal is the input to the 32-bit event counter. The internal counter increments when the TTL level transitions from low to high. The counter can count events at frequencies of up to 1 MHz.

**Caution!** All ground pins on the USB-TC-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Power output

The two **+5V output** terminals are isolated (500 VDC) from the USB +5V.

**Caution!** Each +5V terminal is an output. Do not connect to an external power supply or you may damage the USB-TC-AI and possibly the computer.

## Ground

The six analog ground terminals (**GND**) provide a common ground for the input channels and DIO bits and are isolated (500 VDC) from the USB GND.

## Thermocouple connections

A thermocouple consists of two dissimilar metals that are joined together at one end. When the junction of the metals is heated or cooled, a voltage is produced that correlates to temperature.

The USB-TC-AI makes fully differential thermocouple measurements without the need of ground-referencing resistors. A 32-bit floating point value in either a voltage or temperature format is returned by software. An open thermocouple detection feature is available for each thermocouple input which automatically detects an open or broken thermocouple.

Use *InstaCal* to select the thermocouple type (J, K, R, S, T, N, E, and B) on one or more sensor input channels to connect the thermocouple.

## Wiring configuration

Connect the thermocouple to the USB-TC-AI using a differential configuration, as shown in Figure 3.

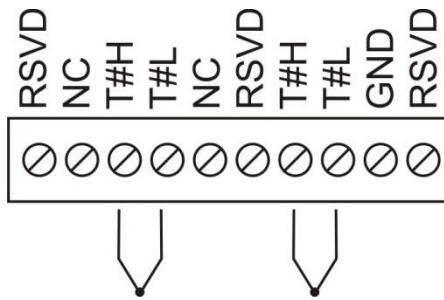


Figure 3. Typical thermocouple connection

Connect thermocouples to the USB-TC-AI such that they are floating with respect to GND (pins 9, 19, 28, 38). The USB-TC-AI **GND** pins are isolated from earth ground, so connecting thermocouple sensors to voltages referenced to earth ground is permissible as long as the isolation between the GND pins (9, 19, 28, 38) and earth ground is maintained.

When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within  $\pm 1.4$  V. For best results, we recommend the use of insulated or ungrounded thermocouples when possible.

#### Maximum input voltage between analog input and ground

The absolute maximum input voltage between an analog input and the isolated GND pins is  $\pm 25$  VDC when the USB-TC-AI is powered on, and  $\pm 40$  VDC when the USB-TC-AI is powered off.

If you need to increase the length of your thermocouple, use the same type of thermocouple wires to minimize the error introduced by thermal EMFs.

## Digital I/O connections

You can connect up to eight digital I/O lines to the screw terminals labeled **DIO0** to **DIO7**. You can configure each digital bit for either input or output. All digital I/O lines are pulled up to +5V with a 47 k $\Omega$  resistor (default). You can request the factory to configure the resistor for pull-down to ground if desired.

When you configure the digital bits for input, you can use the USB-TC-AI digital I/O terminals to detect the state of a TTL-compatible device. Refer to the schematic shown in Figure 4. If you set the switch to the +5V input, DIO0 reads *TRUE* (1). If you move the switch to GND, DIO0 reads *FALSE* (0).

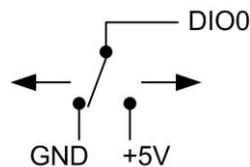


Figure 4. Schematic showing switch detection by digital channel DIO0

All ground pins on the USB-TC-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

For general information regarding digital signal connections and digital I/O techniques, refer to the *Guide to Signal Connections* (available on our web site at [www.mccdaq.com/signals/signals.pdf](http://www.mccdaq.com/signals/signals.pdf)).

# Functional Details

## Thermocouple measurements

A thermocouple consists of two dissimilar metals that are joined together at one end. When the junction of the metals is heated or cooled, a voltage is produced that correlates to temperature.

The USB-TC-AI hardware level-shifts the thermocouple's output voltage into the A/D's common mode input range by applying +2.5 V to the thermocouple's low side at the C#L input. Always connect thermocouple sensors to the USB-TC-AI in a floating fashion. Do not attempt to connect the thermocouple low side C#L to GND or to a ground referencing resistor.

### Cold junction compensation (CJC)

When you connect the thermocouple sensor leads to the sensor input channel, the dissimilar metals at the USB-TC-AI terminal blocks produce two additional thermocouple junctions. This junction creates a small voltage error term which must be removed from the overall sensor measurement using a cold junction compensation technique. The measured voltage includes both the thermocouple voltage and the cold junction voltage. To compensate for the additional cold junction voltage, the USB-TC-AI subtracts the *cold junction* voltage from the thermocouple voltage.

The USB-TC-AI has one high-resolution temperature sensor integrated into the design. The CJC sensor measures the average temperature at the terminal block so that the cold junction voltage can be calculated. A software algorithm automatically corrects for the additional thermocouples created at the terminal blocks by subtracting the calculated cold junction voltage from the analog input's thermocouple voltage measurement.

#### Increasing the thermocouple length

If you need to increase the length of your thermocouple, use the same type of thermocouple wires to minimize the error introduced by thermal EMFs.

### Data linearization

After the CJC correction is performed on the measurement data, an on-board microcontroller automatically linearizes the thermocouple measurement data using National Institute of Standards and Technology (NIST) linearization coefficients for the selected thermocouple type.

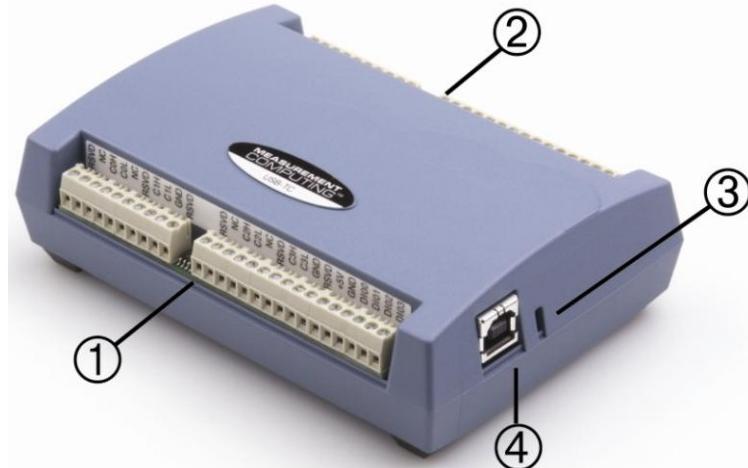
The measurement data is then output as a 32-bit floating point value in the configured format (voltage or temperature).

### Open-thermocouple detection (OTD)

The USB-TC-AI is equipped with open-thermocouple detection for each analog input channel. With OTD, any open-circuit or short-circuit condition at the thermocouple sensor is detected by the software. An open channel is detected by driving the input voltage to a negative value outside the range of any thermocouple output. The software recognizes this as an invalid reading and flags the appropriate channel. The software continues to sample all channels when OTD is detected.

## External components

The USB-TC-AI has the following external components, as shown in Figure 5.



- |   |                              |   |   |
|---|------------------------------|---|---|
| 1 | Screw terminal pins 1 to 26  | 3 | LEDs: Activity (top) and Power (bottom) |
| 2 | Screw terminal pins 27 to 52 | 4 | USB connector                           |

Figure 5.External component locations

### Screw terminals

The screw terminals provide connections for thermocouples, voltage input, digital I/O, ground and power output. Refer to the "Signal I/O Connections**Error! Reference source not found.**" chapter beginning on page 10 for screw terminal descriptions.

### USB connector

The USB connector provides +5V power and communication. No external power supply is required.

### LEDs

USB-TC-AI has two LEDs – **Activity** and **Power**.

- The **Activity** LED (top) blinks when data is transferred.
- The **Power** LED (bottom) turns on when the device is receiving power from the USB cable .

### Power

The two **+5V** terminals are isolated (500 VDC) from the USB **+5V**.

**Caution!** Each **+5V** terminal is an output. Do not connect to an external power supply or you may damage the USB-TC-AI and possibly the computer.

# Specifications

Typical for 25 °C unless otherwise specified.

All specifications apply to all temperature and voltage input channels unless otherwise specified.

Specifications in *italic* text are guaranteed by design.

## Analog input

Table 1. Generic analog input specifications

Parameter	Conditions	Specification
A/D converter type	T0x-T3x, V0x-V3x	AD42_321 Dual 24-bit Sigma-Delta
Number of channels	Voltage input V0x-V3x	4 differential, 4 single-ended
	Temperature input T0x-T3x	4 differential
<i>Input isolation</i>		<i>500 VDC minimum between field wiring and USB interface</i>
Channel configuration	T0x-T3x	Temperature input. Software programmable to match sensor type
	V0x-V3x	Voltage input
Analog input modes	Power up and reset state	Factory default configuration is Disabled mode. Once configured, each channel reverts to the mode previously set by the user.
	Single-ended	Vx_H inputs are connected directly to their screw terminal pins. Vx_L inputs are disconnected from their screw terminal pins and internally connected to GND.
	Differential	Vx_H and Vx_L inputs are connected directly to their screw terminal pins.
		Tx_H and Tx_L inputs are connected directly to their screw terminal pins.
Input ranges	Thermocouple T0x-T3x	±0.080 V
	Voltage V0x to V3x	±10 V, ±5 V, ±2.5 V, ±1.25 V software selectable
<i>Absolute max input voltage</i>	<i>T0x to T3x relative to GND</i>	±25 V max (power on) ±40 V max (power off)
	<i>V0x to V3x relative to GND</i>	±25 V max (power on) ±15 V max (power off)
<i>Input impedance</i>	<i>T0x to T3x</i>	5 GΩ (power on) 1MΩ (power off)
	<i>V0x to V3x</i>	10 GΩ (power on) 2.49 kΩ (power off)
<i>Input leakage current</i>	<i>T0x to T3x, with open thermocouple detect disabled.</i>	30 nA max
	<i>T0x-T3x, with open thermocouple detect enabled.</i>	105 nA max
	<i>V0x to V3x</i>	±1.5 nA typ, ±25 nA max
Input bandwidth (-3 dB)	T0x to T3x	50 Hz
	V0x to V3x	3 kHz
Maximum working voltage (signal + common mode)	V0x to V3x	±10.25 V max

Parameter	Conditions	Specification
<i>Common mode rejection ratio</i>	T0x to T3x, fIN = 60 Hz	100 dB
	V0x to V3x, fIN = 60 Hz, all input ranges	83 dB
ADC resolution		24 bits
ADC No missing codes		24 bits
Input coupling		DC
Warm-up time		30 minutes min
Open thermocouple detect	T0x to T3x	Automatically enabled when the channel pair is configured for thermocouple sensor. The max open detection time is 3 seconds.
<i>CJC sensor accuracy</i>	T0x to T3x, 15 °C to 35 °C	±0.25 °C typ, ±0.5 °C max
	T0x to T3x, 0°C to 70 °C	-1.0 to +0.75 °C max

## Channel configurations

Table 2. Channel configuration specifications

Channel	Category	Conditions	Specification
T0x to T3x	Disabled	All temperature input channels are disconnected from screw terminals and internally connected to GND.	See Note 4
T0x to T3x	Thermocouple Note 1		4 differential channels
V0x to V3x	Disabled	All voltage input channels are disconnected from screw terminals and internally connected to GND.	See Note 4
V0x to V3x	Differential Note 2		4 differential channels
V0x to V3x	Single-ended		4 single-ended channels

**Note 1:** Internally, the USB-TC-AI has four, dual-channel, fully differential A/Ds providing a total of eight input channels.

**Note 2:** When connecting differential inputs to floating input sources, you must provide a DC return path from each differential input to ground. To do this, connect a resistor from each of the differential inputs to GND. A value of approximately 1Meg ohm can be used for most applications.

**Note 3:** Channel configuration information is stored in the EEPROM of the isolated microcontroller by the firmware whenever any item is modified. Modification is performed by commands issued over USB from an external application, and the configuration is made non-volatile through the use of the EEPROM.

**Note 4:** The factory default configuration is *Disabled*. The Disabled mode will disconnect the temperature and voltage inputs from the terminal blocks and internally connect ground (GND) to all of the A/D inputs.

## Compatible sensors: T0x to T3x

Table 3. Compatible sensor type specifications

Parameter	Conditions (°C)
Thermocouple	J: -210 to 1200
	K: -270 to 1372
	R: -50 to 1768
	S: -50 to 1768
	T: -270 to 400
	N: -270 to 1300
	E: -270 to 1000
	B: 0 to 1820

## Accuracy

### Thermocouple measurement accuracy: T0x to T3x

Table 4. Thermocouple accuracy specifications, including CJC measurement error. All specifications are ( $\pm$ )

Sensor Type	Sensor temperature range (°C)	Accuracy error maximum (°C)	Accuracy error Typical (°C)	Tempco (°C/°C)
J	-210	2.028	0.707	0.031
	0	0.835	0.278	
	1200	0.783	0.288	
K	-210	2.137	0.762	0.035
	0	0.842	0.280	
	1372	0.931	0.389	
S	-50	1.225	0.435	0.021
	250	0.554	0.195	
	1768	0.480	0.157	
R	-50	1.301	0.458	0.019
	250	0.549	0.190	
	1768	0.400	0.134	
B	250	2.193	2.185	0.001
	700	0.822	0.819	
	1820	0.469	0.468	
E	-200	1.976	0.684	0.030
	0	0.954	0.321	
	1000	0.653	0.240	
T	-200	2.082	0.744	0.035
	0	0.870	0.290	
	400	0.568	0.208	
N	-200	2.197	0.760	0.028
	0	0.848	0.283	
	1300	0.653	0.245	

**Note 5:** Thermocouple measurement accuracy specifications include polynomial linearization, cold-junction compensation and system noise. These specs are for one year, or 3000 operating hours, whichever comes first, and for operation of the USB-TC-AI between 15 °C and 35 °C. There is a CJC sensor on the temperature sensor input side of the module. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Errors shown do not include inherent thermocouple error. Contact your thermocouple supplier for details on the actual thermocouple accuracy error.

**Note 6:** Thermocouples must be connected to the USB-TC-AI such that they are floating with respect to GND. The USB-TC-AI GND pins are isolated from earth ground. You can connect thermocouple sensors to voltages referenced to earth ground as long as the isolation between the GND pins and earth ground is maintained.

**Note 7:** When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within  $\pm 1.4$  V. For best results, we recommend using insulated or ungrounded thermocouples when possible.

## Absolute accuracy: V0x-V3x

Table 5. Calibrated absolute accuracy specifications

Range	Absolute Accuracy (mV)
±10 V	±2.779
±5 V	±1.398
±2.5 V	±0.707
±1.25 V	±0.362

**Note 8:** When connecting differential inputs to floating input sources, the user must provide a ground return path from each differential input to ground. To do this, simply connect a resistor from each of the differential inputs to GND. A value of approximately 1Meg ohm can be used for most applications.

**Note 9:** All ground pins are common and are isolated from earth ground. If a connection is made to earth ground when using both voltage inputs and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground

**Note 10:** Unused voltage inputs should not be left floating. These inputs should be placed in the Disabled mode or connected to GND.

Table 6. Accuracy components. All values are (±)

Range	Gain error (% of reading)	Offset error (µV)	INL error (% of range)	Gain Temperature Coefficient (ppm/°C)	Offset Temperature Coefficient (µV/°C)
±10 V	0.0246	16.75	0.0015	3.68	0.42
±5 V	0.0246	16.75	0.0015	3.68	0.42
±2.5 V	0.0246	16.75	0.0015	3.68	0.42
±1.25 V	0.0246	16.75	0.0015	3.68	0.42

Table 7. Noise performance specifications

Range	Peak to peak noise (µV)	RMS noise (µVrms)	Noise-Free resolution (bits)
±10 V	41.13	6.23	19.09
±5 V	30.85	4.67	18.51
±2.5 V	17.14	2.60	18.36
±1.25 V	11.14	1.69	17.98

Table 7 summarizes the noise performance for the USB-TC-AI. Noise distribution is determined by gathering 1000 samples with inputs tied to ground at the user connector. Samples are gathered at the maximum specified sample rate of 2 S/s.

## Settling time: V0x-V3x

Table 8. Settling time specifications

Range	Accuracy
	±0.0004% (seconds)
±10 V	15.0
±5 V	0.40
±2.5 V	0.40
±1.25 V	0.40

Settling time is defined as the time required for a channel to settle within a specified accuracy in response to a full-scale (FS) step input.

## Analog input calibration

Table 9. Analog input calibration specifications

Parameter	Specification
Recommended warm-up time	30 minutes min
Calibration	Firmware calibration
Calibration interval	1 year
Calibration reference	+10.000 V, $\pm 5$ mV max. Actual measured values stored in EEPROM Tempco: 5 ppm/ $^{\circ}$ C max Long term stability: 30 ppm/1000 h

## Throughput rate

Table 10. Throughput rate specifications

Number of Input Channels	Maximum throughput
1	2 S/s
2	2 S/s on each channel, 4 S/s total
3	2 S/s on each channel, 6 S/s total
4	2 S/s on each channel, 8 S/s total
5	2 S/s on each channel, 10 S/s total
6	2 S/s on each channel, 12 S/s total
7	2 S/s on each channel, 14 S/s total
8	2 S/s on each channel, 16 S/s total

**Note 11:** The analog inputs are configured to run continuously. Each channel is sampled twice per second. The maximum latency between when a sample is acquired and the voltage/temperature data is provided by the USB unit is approximately 0.4 seconds.

## Digital I/O

Table 11. Digital input/output specifications

Parameter	Specification
Digital type	5V CMOS
Number of I/O	8 (DIO0 through DIO7)
Configuration	Independently configured for input or output. Power on reset is input mode.
Pull-up/pull-down configuration	All pins pulled up to +5 V via 47 K resistors (default). Contact MCC factory for pull-down to ground (GND) capability.
Digital I/O transfer rate (software paced)	<ul style="list-style-type: none"> <li>▪ Digital input: 50 port reads or single bit reads per second typ</li> <li>▪ Digital output: 100 port writes or single bit writes per second typ</li> </ul>
Input high voltage	2.0 V min, 5.5 V absolute max.
Input low voltage	0.8 V max, -0.5 V absolute min
Output low voltage (IOL = 2.5 mA max)	0.7 V max
Output high voltage (IOH = -2.5 mA max)	3.8 V min

**Note 12:** All ground pins on the USB-TC-AI (pins 9, 19, 22, 27, 30, 33, 36, 39, 49) are common and are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Temperature alarms

Table 12. Temperature alarm specifications

Parameter	Specification
Number of alarms	8 (one per digital I/O line)
Alarm functionality	Each alarm controls its associated digital I/O line as an alarm output. The input to each alarm may be any of the analog temperature input channels. When an alarm is enabled, its associated I/O line is set to output (after the device is reset) and driven to the appropriate state determined by the alarm options and input temperature. The alarm configurations are stored in non-volatile memory and are loaded at power on. Alarms will function both in data logging mode and while attached to USB.
Alarm input modes	<ul style="list-style-type: none"> <li>▪ Alarm when input temperature &gt; T1</li> <li>▪ Alarm when input temperature &gt; T1, reset alarm when input temperature goes below T2</li> <li>▪ Alarm when input temperature &lt; T1</li> <li>▪ Alarm when input temperature &lt; T1, reset alarm when input temperature goes above T2</li> <li>▪ Alarm when input temperature is &lt; T1 or &gt; T2</li> </ul> <p><b>Note:</b> T1 and T2 may be independently set for each alarm.</p>
Alarm output modes	<ul style="list-style-type: none"> <li>▪ Disabled, digital I/O line may be used for normal operation</li> <li>▪ Enabled, active high output (digital I/O line goes high when alarm conditions met)</li> <li>▪ Enabled, active low output (digital I/O line goes low when alarm conditions met)</li> </ul>
Alarm update rate	1 second

## Counter

Table 13. CTR I/O specifications

Parameter	Specification
Pin name	CTR
Number of channels	1
Resolution	32-bits
Counter type	Event counter
Input type	TTL, rising edge triggered
Input source	CTR screw terminal
Counter read/writes rates (software paced)	Counter read: system dependent, 33 to 1000 reads per second. Counter write: system dependent, 33 to 1000 reads per second.
Schmidt trigger hysteresis	20 mV to 100 mV
<i>Input leakage current</i>	$\pm 1.0 \mu\text{A}$ typ
Input frequency	1 MHz max
<i>High pulse width</i>	500 nS min
<i>Low pulse width</i>	500 ns min
Input high voltage	4.0 V min, 5.5 V absolute max
Input low voltage	1.0 V max, -0.5 V absolute min

**Note 13:** All ground pins are common and are isolated from earth ground. If a connection is made to earth ground with both the counter (CTR) and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Memory

Table 14. Memory specifications

Parameter	Specification
EEPROM	1,024 bytes isolated micro reserved for sensor configuration 256 bytes USB micro for external application use

## Microcontroller

Table 15. Microcontroller specifications

Parameter	Specification
Type	Two high-performance 8-bit RISC microcontrollers

## USB +5V voltage

Table 16. USB +5V voltage specifications

Parameter	Specification
USB +5V (VBUS) input voltage range	4.75 V min to 5.25 V max

## Power

Table 17. Power specifications

Parameter	Conditions	Specification
Supply current	USB enumeration	<100 mA
Supply current (Note 14)	Continuous mode with all inputs configured for Disabled mode.	270 mA typ
User +5V output voltage range (terminal block pin 21)		4.9 V min to 5.1 V max
User +5V output current (terminal block pin 21)	Bus-powered and connected to a self-powered hub. (Note 14)	5 mA max
Isolation	Measurement system to PC	500 VDC min

**Note 14:** This is the total current requirement for the USB-TC-AI which includes up to 10 mA for the status LED.

## USB specifications

Table 18. USB specifications

Parameter	Specification
USB device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
Device power capability	Self-powered
USB cable type	A-B cable, UL type AWM 2725 or equivalent. (min 24 AWG VBUS/GND, min 28 AWG D+/D-)
USB cable length	3 meters max

## Environmental

Table 19. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 55 °C max
Storage temperature range	-40 °C to 85 °C max
Humidity	0% to 90% non-condensing max

## Mechanical

Table 20. Mechanical specifications

Parameter	Specification
Dimensions (L × W × H)	128.52 x 88.39 x 35.56 mm (5.06 x 3.48 x 1.43 ft)
User connection length	3 m (9.84 ft) max

## Screw terminal connector

Table 21. Screw terminal connector specifications

Parameter	Specification
Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

Table 22. Screw terminal pinout

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	RSVD	Reserved, Do Not Use	27	GND	Ground
2	NC	No connection	28	V3L	V3 voltage input (-)
3	T0H	T0 sensor input (+)	29	V3H	V3 voltage input (+)
4	T0L	T0 sensor input (-)	30	GND	Ground
5	NC	No connection	31	V2L	V2 voltage input (-)
6	RSVD	Reserved, Do Not Use	32	V2H	V2 voltage input (+)
7	T1H	T1 sensor input (+)	33	GND	Ground
8	T1L	T1 sensor input (-)	34	V1L	V1 voltage input (-)
9	GND	Ground	35	V1H	V1 voltage input (+)
10	RSVD	Reserved, Do Not Use	36	GND	
	CJC sensor				
11	RSVD	Reserved, Do Not Use	37	V0L	V0 voltage input (-)
12	NC	No connection	38	V0H	V0 voltage input (+)
13	T2H	T2 sensor input (+)	39	GND	Ground
14	T2L	T2 sensor input (-)	40	CTR	Counter Input
15	NC	No connection	41	DIO7	DIO channel 7
16	RSVD	Reserved, Do Not Use	42	DIO6	DIO channel 6
17	T3H	T3 sensor input (+)	43	DIO5	DIO channel 5
18	T3L	T3 sensor input (-)	44	DIO4	DIO channel 4
19	GND	Ground	45	DIO3	DIO channel 3
20	RSVD	Reserved, Do Not Use	46	DIO2	DIO channel 2
21	+5V	+5V output	47	DIO1	DIO channel 1
22	GND	Ground	48	DIO0	DIO channel 0
23	NC	No connection	49	GND	Ground
24	NC	No connection	50	NC	No connection
25	NC	No connection	51	NC	No connection
26	NC	No connection	52	NC	No connection

# CE Declaration of Conformity

Manufacturer: Measurement Computing Corporation  
Address: 10 Commerce Way  
Suite 1008  
Norton, MA 02766  
USA  
Category: Electrical equipment for measurement, control and laboratory use.

Measurement Computing Corporation declares under sole responsibility that the product

## USB-TC-AI

EU EMC Directive 89/336/EEC: Electromagnetic Compatibility, EN 61326 (1997) Amendment 1 (1998)

Emissions: Group 1, Class A

- EN 55011 (1990)/CISPR 11: Radiated and Conducted emissions.

Immunity: EN61326, Annex A

- IEC 61000-4-2 (1995): Electrostatic Discharge immunity, Criteria C.
- IEC 61000-4-3 (1995): Radiated Electromagnetic Field immunity Criteria A.
- IEC 61000-4-8 (1994): Power frequency magnetic field immunity Criteria A.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in July, 2007. Test records are outlined in Chomerics Test Report #EMI4833.07.

We hereby declare that the equipment specified conforms to the above Directives and Standards.



Carl Haapaoja, Director of Quality Assurance

**Measurement Computing Corporation**  
**10 Commerce Way**  
**Suite 1008**  
**Norton, Massachusetts 02766**  
**(508) 946-5100**  
**Fax: (508) 946-9500**  
**E-mail: [info@mccdaq.com](mailto:info@mccdaq.com)**  
**[www.mccdaq.com](http://www.mccdaq.com)**